Capacitativly Coupled Chebychev BPF

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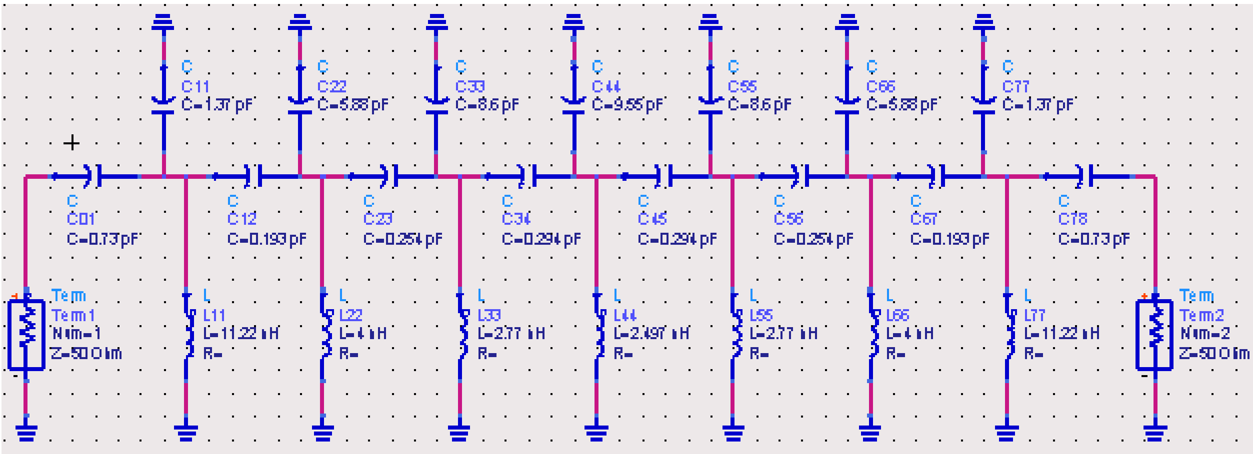


This sheet is used to design a **microwave capacitatively coupled BPF**. The maths for this filter is modified from "Theory & Design of Microwave Filters", Ian Hunter, IEE Press.

The schematic that is designed and simulated is shown above for N=7, BW=50MHz, 30dB return loss.

Main user input area:

$\mu m := 10^{-6} \cdot m$ $\quad nH := 10^{-9} \cdot henry$

$L_{ar\_db} := 30$ Passband return loss in dB

$N := 7$ Order of the filter, this needs to be above 2 and even numbers.

$f_{gm} := 1 \cdot GHz$ $\quad Z_o := 50 \cdot \mathbf{O}$ $\quad bandwidth := 50 \cdot MHz$

Start Calculating...

$$f_{low} := f_{gm} - \frac{bandwidth}{2} \qquad f_{high} := f_{gm} + \frac{bandwidth}{2} \qquad bw := \frac{f_{high} - f_{low}}{f_{gm}}$$

$$f_{bp}(f) := \frac{1}{bw} \cdot \left(\frac{f}{f_{gm}} - \frac{f_{gm}}{f} \right) \cdot f_{gm} \qquad bwpercent := bw \cdot 100 \qquad \mathbf{a} := \frac{f_{gm}}{bandwidth}$$

$bwpercent = 5$

$\mathbf{a} = 20$

LPF Frequency Response, for Chebychev Polynomials

This section plots the frequency response for the Chebychev BPF

$$Y_o := \frac{1}{Z_o} \qquad \mathbf{e} := \left(10^{\frac{L_{ar\_db}}{10}} - 1 \right)^{-0.5}$$

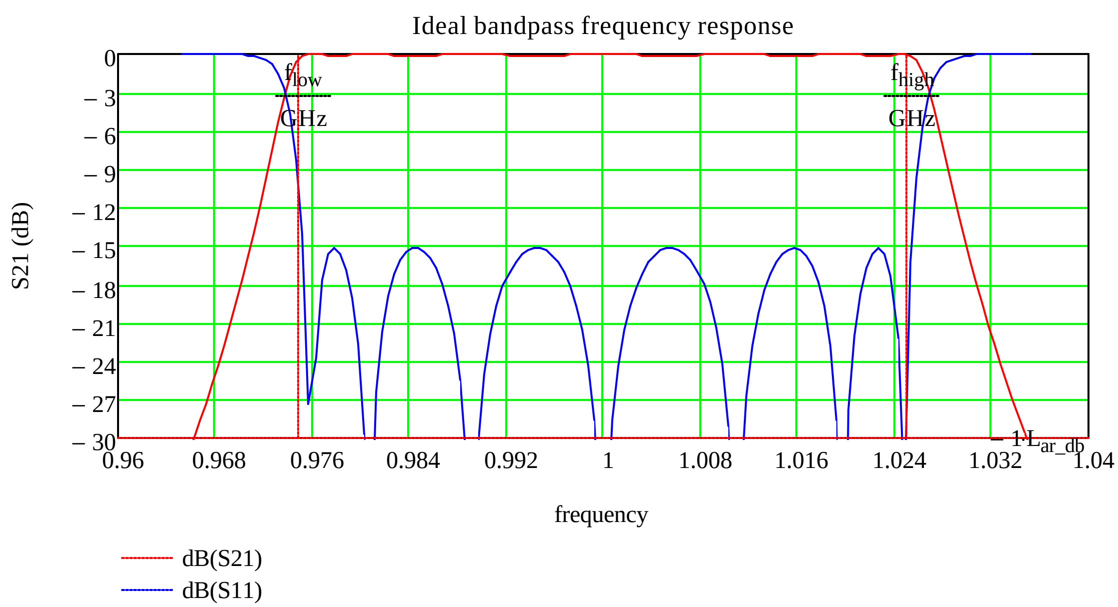
$\mathbf{e} = 0.03164$

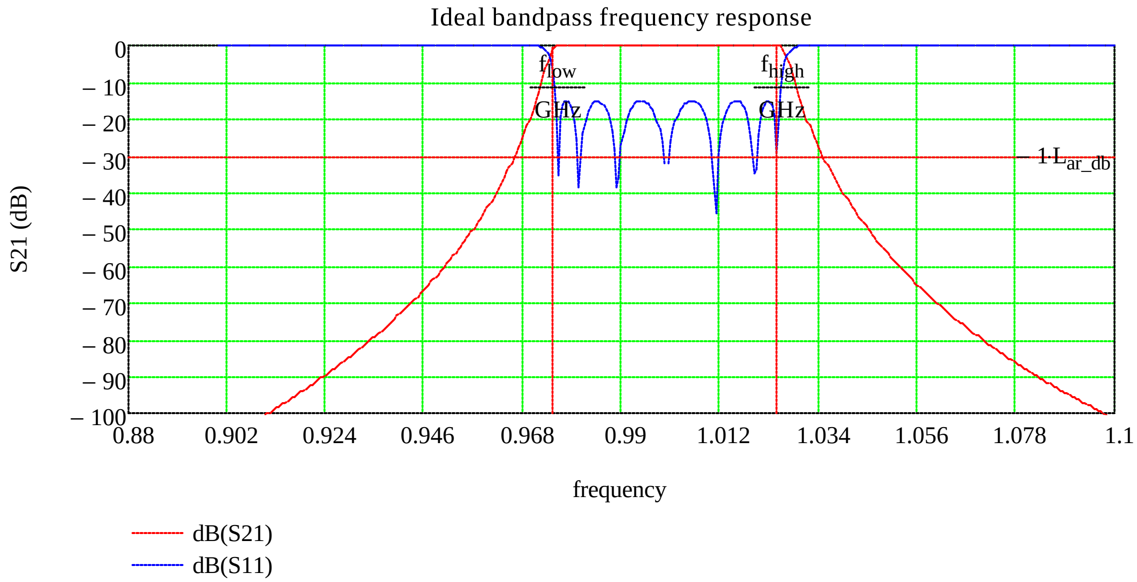
$$L_A(f,f_c) := \left|\begin{array}{ll} 10\cdot\log\left[1+\mathbf{e}\cdot\left(\cos\left(N\cdot\operatorname{acos}\left(\frac{f}{f_c}\right)\right)\right)^2\right] & \text{if } f\le f_c \\ 10\cdot\log\left[\left[1+\mathbf{e}\cdot\left(\cosh\left(N\cdot\operatorname{acosh}\left(\frac{f}{f_c}\right)\right)\right)^2\right]\right] & \text{if } f>f_c \end{array}\right.$$

$$S11_A(f,f_1) := 10\cdot\log\left[1-10^{\left(\frac{-L_A(f,f_1)}{10}\right)}\right]$$

$$f\_bp\_narrow := 0.99\cdot f_{low}, \frac{f_{high}-f_{low}}{100}+0.99\cdot f_{low} .. 1.01\cdot f_{high}$$

$$f\_bp\_wide := (f_{gm}-2\cdot f_{gm}\cdot bw), (f_{gm}-2\cdot f_{gm}\cdot bw)+\frac{f_{gm}\cdot bw}{100} .. f_{gm}+(2\cdot f_{gm}\cdot bw)$$





Calculate the circuit values.....

$$? := \sinh\left(\frac{1}{N}\cdot \operatorname{asinh}\left(\frac{1}{\mathbf{e}}\right)\right)$$

$$n := 1, 2 .. N$$

$$nn := 1, 2 .. N - 1$$

$$nnn := 0, 1 .. N$$

$$K_{nn,nn+1} := \frac{\left[?^2 + \left(\sin\left(\frac{nn\cdot \mathbf{p}}{N}\right)\right)^2\right]^{0.5}}{?}$$

$$C_n := \frac{2}{?}\sin\left[\frac{(2\cdot n - 1)\cdot \mathbf{p}}{2\cdot N}\right]$$

$$Cap_{0,1} := \frac{1}{\left[2\cdot \mathbf{p}\cdot f_{gm}\cdot(\mathbf{a} - 1)^{0.5}\cdot Z_o\right]} \qquad Cap_{N,N+1} := \frac{1}{\left[2\cdot \mathbf{p}\cdot f_{gm}\cdot(\mathbf{a} - 1)^{0.5}\cdot Z_o\right]} \qquad Cap_{0,1} = 0.730\cdot pF$$

$$Ind_{n,n} := \frac{Z_o}{C_n\cdot 2\cdot \mathbf{p}\cdot f_{gm}} \qquad Cap_{nn,nn+1} := \frac{K_{nn,nn+1}}{\mathbf{a}\cdot 2\cdot \mathbf{p}\cdot f_{gm}\cdot Z_o}$$

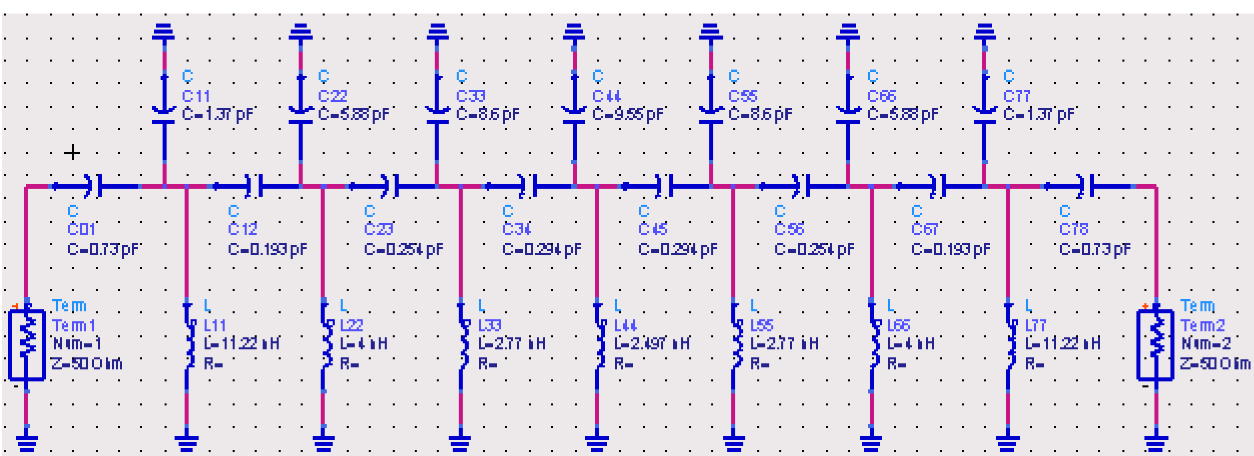
$$Cap_{n,n} := \frac{C_n}{2\cdot \mathbf{p}\cdot f_{gm}\cdot Z_o} - Cap_{n-1,n} - Cap_{n,n+1}$$

$$Cap_{1,1} := \frac{C_1}{2\cdot \mathbf{p}\cdot f_{gm}\cdot Z_o} - \frac{(\mathbf{a} - 1)^{0.5}}{2\cdot \mathbf{p}\cdot f_{gm}\cdot Z_o\cdot \mathbf{a}} - Cap_{1,2} \qquad Cap_{N,N} := Cap_{1,1}$$

$C_n =$
0.709
1.987
2.871
3.186
2.871
1.987
0.709

$K_{nn,nn+1} =$
1.216
1.597
1.847
1.847
1.597
1.216

$Cap_{n,n} =$ ($\cdot$ p)	$Ind_{n,n} =$ ($\cdot$ n])	$Cap_{nnn,nnn+1} =$ ($\cdot$ pF)
1.370	11.223	0.730
5.876	4.005	0.193
8.590	2.772	0.254
9.555	2.497	0.294
8.590	2.772	0.294
5.876	4.005	0.254
1.333	11.223	0.193
		0.730



Simulation Results

To test the calculations I have run a simulation on ADS for N = 7, Return Loss = 30dB, Zo = 50R.

You can see the results are in reasonable agreement. The ripple and return loss (S11) are better in the simulation. The bandwidth is excellent.